OSGeo Live: Open Source GIS software for Land Reform and Developing Geomatics in Africa

Cameron Shorter\textsuperscript{1}, Gavin Fleming\textsuperscript{2}

\textsuperscript{1}OSGeo / LISASoft, Australia
\textsuperscript{2}OSGeo / AfriSpatial, South Africa, gavinjfleming@gmail.com

Abstract

Open Source GIS is diverse and mature and enjoyed by a growing community. This paper will take you on a whirlwind tour of many of the FOSS GIS applications available, covering all aspects of the GIS industry and including tools that can be used to support land reform and developing geomatics. It uses as a basis the OSGeo Live DVD, which is a bootable disk containing all the software pre-installed and operational.

1. Introduction

This presentation provides a lightning overview of the breadth of quality geospatial open source applications that are available for the full range of geospatial use cases, including storage, publishing, viewing, analysis and manipulation of data. The paper is based upon documentation from OSGeo Live, which is a self-contained DVD, USB thumb drive and Virtual Machine, based on Xubuntu. It includes close to fifty of the best geospatial open source applications, pre-configured with data, project overviews and quick-starts, translated into multiple languages. It is an excellent tool for demonstrating geospatial Open Source, using with tutorials and workshops, or providing to potential new users.

This paper is useful for anyone wishing to gain a high level understanding of the breadth and robustness of geospatial open source available.

Note that all software covered in this paper is Free and Open Source (FOSS) and therefore not proprietary. All of these technologies are community-run software projects as opposed to products. Their names are not proprietary brand names. No-one owns them or profits by selling them. They are all freely available to download and install, customise and develop.

2. How things fit together

Figure 1 shows the generic architecture of an enterprise GIS and where a selection of FOSS GIS packages fit. The group of software that makes up a GIS is commonly called a 'stack'.
3. What is OSGeo Live?

OSGeo Live is a self-contained bootable DVD, based on the Xubuntu Linux distribution, that is pre-installed and pre-configured with close to fifty of the best Geospatial Open Source applications along with sample datasets. OSGeo-Live can also be run from a USB flash drive, installed into a Virtual Machine, or installed onto your hard drive. It contains overview and quickstart documentation for each application, as well as documentation about key OGC (Open Geospatial Consortium) spatial standards. The DVD is ideal for handing out at conferences, using in workshops, and trialling a range of Open Source Software.
To try OSGeo-Live applications, simply:
1. Insert a DVD or USB thumb drive in your computer or virtual machine.
2. Reboot your computer.
3. Press "Enter" a few times.
4. Then select applications from the "GeoSpatial" menu.

OSGeo-Live derives its name from the Open Source GeoSpatial Foundation, or OSGeo for short. The OSGeo Live DVD itself is managed like an open source project, with over seventy volunteers around the world packaging and compiling software, writing overviews and quickstarts and documentation; and hundreds more testing and giving feedback.

3.1. OSGeo
The OSGeo Foundation was set up in 2006 as a non-profit umbrella organisation to support development and promotion of quality Geospatial Open Source Software and Open Data.

3.2. OGC
Open Source applications have a reputation for excellent standards compliance. Notably, the OGC uses Open Source projects when defining reference implementations for standards. OSGeo-Live includes overviews of key OGC standards in simple language so they can be understood by people without a technical background.

Building Spatial Data Infrastructures (SDIs) using standards, facilitates interoperability between proprietary and open source applications. It facilitates sharing data between agencies. It reduces long term costs associated with data maintenance, and it reduces long term project risk by avoiding dependence upon proprietary formats or products, thus avoiding vendor lock-in.

The rest of the paper will focus on a selection of the packages on OSGeo Live one by one, grouped by their place in the stack.

4. Databases
We will start our overview of applications at the bottom of the stack with the databases.

4.1. PostGIS
PostGIS spatially enables the popular PostgreSQL object-relational database, allowing it to be used as a back-end database for geographic information systems and web-mapping applications in the same manner as Oracle Spatial enables the Oracle database. PostGIS is stable, fast, standards compliant, comes with hundreds of spatial functions and is currently the most widely used Open Source spatial database. PostGIS is used by diverse organisations from around the world, including risk-averse government agencies and organisations storing terabytes of data and serving millions of
web requests per day. Database administration is available via pgAdmin and other tools. Importing and exporting data is provided by various converter tools and there are numerous desktop and browser GIS clients for viewing PostGIS data.

![Figure 3: Views of PostGIS tables in pgAdmin](image)

4.2. **pgRouting**

pgRouting extends the PostGIS database to provide geospatial routing functionality so you can apply queries like finding the shortest path between points from within the database, thus simplifying both routing functionality and maintenance of data.

4.3. **SpatiaLite**

SpatiaLite adds spatial functionality to the popular SQLite database. SQLite is a self-contained, zero-administration, relational database, which can be built into applications without needing a database server. Each SQLite data store is kept in one file, which can easily be copied between platforms and around the Internet without complication.

4.4. **Rasdaman**

Rasdaman is a data store for storing, querying and analysing multi-dimensional raster data. It is used for datasets such as a thematic map of the world, where the colour of each pixel represents a different temperature. The multi-dimensional part means that each pixel can store multiple attributes, such as air pressure, humidity, and wind speed.

5. **Web Services**

Moving up the stack are the Web Services which are accessed via a URL, and return map data in various formats. Data is primarily accessed via OGC standards-based interfaces, including Web Map Services for images, Web Feature Services for vector data and Catalog Services for the Web for Metadata.
5.1. **Mapserver**

Mapserver is one of the earliest Open Source Web Map Services. The code-base is very mature and it retains a large development community. It serves data through Web Map Service images, non-transactional Web Feature Service vectors, a Web Coverage Service and Sensor Observation Services. It connects to a wide range of databases and data stores. It is written in C and has connections for a number of other languages.

5.2. **GeoServer**

GeoServer contains similar functionality to Mapserver. As well as providing a Web Map Service interface, it holds the title of being the OGC reference implementation for the Transactional Web Feature Service and the Web Coverage Service standards. Included with GeoServer is GeoWebCache, which supports tiling of base maps for fast map delivery. GeoServer comes with a nice browser-based management interface with OpenLayers map viewer built in. GeoServer is built upon many of the same java libraries used by java-based desktop applications, and through these libraries accesses a wide range of back-end databases and data stores.

5.3. **QGIS Server**

QGIS Server provides a web map service based on the popular QGIS desktop application. The close integration with QGIS means desktop maps can easily be exported to web maps by copying the QGIS project file into the server directory, and a nice touch is that the web maps look exactly the same as they do in the desktop.

![Figure 4: Setting up a map for publication in QGIS](image)

5.4. **MapTiler**

MapTiler provides a desktop interface for creating tiles, which can then be stored on the local file-system or published via direct upload to any web-server or cloud storage. Browser viewing is provided by OpenLayers and Google Maps and can be easily customised.
5.5. **Zoo**

The ZOO Project provides a developer-friendly Web Processing Service (WPS) framework for creating and chaining Web Processing Services. A Web Processing Service provides web access to functions which run spatial algorithms. Zoo Project supports many programming languages and comes with C and Python examples.

5.6. **52 Degrees North SOS**

The 52° North Sensor Observation Service (SOS) provides a standards based interface for reading of live and archived data captured by *in situ* and remote sensors. Sensors are things like a camera on a satellite or a water level meter in a stream.

5.7. **GeoNetwork**

GeoNetwork provides a catalogue, which is used to create, maintain and search metadata about specific datasets. Metadata is “data about data”, storing such things as creation-date, author, title, area-of-interest, and so on. Metadata is usually encoded as XML files, following international standards. GeoNetwork provides powerful metadata editing and search functions, an embedded interactive web map viewer, and is the OGC’s reference implementation for the "Catalogue Services for the Web" standard.

6. **Web Clients**

We will now move from Web Services to browser-based clients. Browser clients are increasingly being used to deliver a wide range of tools and functions previously only available in desktop applications.

6.1. **OpenLayers**

OpenLayers is one of the more popular choices for building web mapping sites and provides an extensive set of browser-based mapping tools and widgets, similar to Google Maps. All functionality runs inside the web browser, which makes OpenLayers easy to install, without any server-side dependencies.

6.2. **MapFish**

MapFish incorporates OpenLayers with the cross-browser widgets provided by ExtJS and GeoExt, as well as the Pylons web framework, thus incorporating browser tools with server-side functionality.
7. Desktop

We'll now move from the browser to desktop, where we find the heavy lifting applications.

7.1. GRASS GIS

GRASS GIS provides powerful raster, vector, and geospatial processing. It includes tools for spatial modelling, visualisation of raster and vector data, management and analysis of geospatial data, and the processing of satellite and aerial imagery. It also provides the capability to produce sophisticated presentation graphics and hardcopy maps. GRASS is used around the world in academic and commercial settings as well as by many governmental agencies and environmental consulting companies. The GRASS software includes over 400 built-in analysis modules and 100 community supplied modules and toolboxes. After 27 years of continuous development GRASS is both the oldest and largest Open Source GIS available. It is capable of very powerful analysis, but may not be as simple to get started with as other offerings with more of a geodata viewer focus. Many Open Source projects make use of GRASS's algorithms.

Figure 6: GRASS GIS. GRASS also comes with QGIS as a plugin.
7.2. **QGIS**

QGIS is a very popular user-friendly GIS client which allows you to visualize, manage, edit, analyse data, and compose printable maps. It supports numerous vector, raster and database formats, and boasts many free toolboxes, including a user-friendly interface to the advanced GRASS, SAGA, Sextante and Orfeo Toolbox analysis modules.

7.3. **gvSIG**

In 2003, the Ministry for Transport and Infrastructure in Valencia, Spain, started migrating all their systems to Open Source Software. Part of this migration involved the development of gvSIG to replace ESRI desktop applications in use. gvGIS is a desktop GIS application designed for capturing, storing, handling, analysing and deploying any kind of referenced geographic information in order to solve complex management and planning problems. gvSIG is available in over 20 languages, and has a very strong following amongst Spanish speakers. gvSIG is also available in a mobile version which integrates with the desktop application.

7.4. **uDig**

uDig is a java-based spatial data viewer and editor, which is based upon the GeoTools library and powerful Eclipse development environment, making uDig a common choice for developers wishing to integrate mapping into java based applications.

7.5. **MapWindow**

MapWindow GIS is a desktop client specifically written to integrate with windows based applications as it is based upon ActiveX controls. As such it is easy to incorporate into Microsoft Office based products such as Excel and Access, as well as programs written in VisualBasic, C++, C#, .NET, and Delphi. MapWindow provides tools to visualise, manage, edit, analyse data, and compose printable maps.

7.6. **OSSIM**

The Open Source Software Image Map, often referred to as OSSIM, or Awesome Image Processing, is a high performance engine for remote sensing, image processing, geographical information systems and photogrammetry. OSSIM has been funded by several US government agencies in the intelligence and defence communities. It has been actively developed since 1996 and the technology is deployed in research and operational sites. Designed as a series of high performance software libraries written in C++, it includes many command line utilities, GUI applications, and integrated systems.

8. **Spatial Tools**

The next category we have grouped together are Spatial Tools.
8.1. ORFEO Toolbox

ORFEO Toolbox is a high performance image processing library, funded by the French Space Agency. It is primarily used for processing remote sensing images such as those gathered by radars, satellites and aerial photography. It provides tools for the future optic and radar images such as tri-dimensional aspects, change detection, texture analysis, and pattern matching.

![Image processing in ORFEO toolbox. Also available as a QGIS plugin.](image)

8.2. Mapnik

Mapnik is a toolkit for rendering beautiful maps, with clean, soft edges for features provided by quality anti-aliasing graphics, also intelligent label placement, and scalable, SVG symbolisation. Most famously, mapnik is used to render the OpenStreetMap layers. Mapnik has typically been embedded in python applications which deliver their maps over the internet and recent scaling improvements have meant that Mapnik is starting to be used to create high resolution paper maps too.

![Mapnik is used to render beautiful cartography like that in OpenStreetMap](image)
8.3. R

R is a powerful, widely-used software environment for statistical computing and graphics which excels at analysing and processing geographic data sets. Geospatial analysis capabilities provide access to a large number of traditional and state of the art algorithms, often before they are available in other open source or proprietary software. R and its packages are able to process point, line, polygon and grid data. Users can accomplish a broad array of tasks such as: image classification and statistical analysis to infer spatial relationships and patterns of features. The core R interface is a command line window which provides excellent flexibility and control but tends to lengthen the time required to become a proficient user when compared to a graphical user interface. Fortunately R is well documented on the website which eases the learning process.

8.4. GeoKettle

GeoKettle is a “spatially-enabled” version of Pentaho Data Integration, a powerful "Extract, Transform and Load" tool, or ETL tool. GeoKettle compares with the proprietary FME. GeoKettle is particularly useful for automating complex and repetitive data processing between different formats and databases, without producing specific code. GeoKettle is used by diverse organisations from around the world, including governmental agencies, banks, insurance and geospatial system integrators.

9. Crisis Management

Crowd sourcing and Open Source has proven itself to be incredibly effective in Crisis Management situations, and we show a couple of projects here that are actively used.

9.1. Sahana

Sahana is a web-based collaboration tool that addresses the common coordination problems during a disaster. From finding missing people, managing aid, managing volunteers, and tracking camps effectively between Government groups, NGOs and the victims themselves. The Sahana project was initiated by volunteers in Sri Lanka during the 2004 Asian Tsunami. The system was officially used by the Government and then released as Free and Open Source software. It is built with web2py and GeoExt.
9.2. Ushahidi

Ushahidi is an open source platform that allows anyone to gather distributed data via SMS, email or the web and visualize it on a map or timeline. It facilitates democratizing information, increasing transparency and lowering the barriers for individuals to share their stories. Ushahidi, which means "testimony" in Swahili, was initially developed to map reports of violence in Kenya after the post-election fallout at the beginning of 2008 and attracted 45,000 users in its first deployment.

10. Map Data

Of course, all these free tools become much more useful with access to free mapping data.

10.1. Natural Earth

And that is the focus of the Natural Earth project.

Natural Earth provides cartographers public domain maps for creating small-scale world, regional, and country maps at a range of scales. Both political and physical features are included in both vector and raster formats, and vector features align perfectly with raster layers.
10.2. OpenStreetMap
OpenStreetMap is a project which has crowd sourced street maps of the entire world, using the same collaborative editing principles as Wikipedia. By early 2010 there were nearly 250,000 registered Open Street Map users, 10% of whom regularly contribute to the base map every month. The OSGeo Live DVD contains a small extract of OpenStreetMap data which is used by some quickstart examples. A range of Open Street Map's tools are also installed, including viewers, editors, a routing engine, renderer, and a tool for loading Open Street Map data into the Postgres database.

11. Geospatial Libraries
Many of the applications described so far are built upon software libraries. We will now look at key libraries which have shown a level of quality by going through the OSGeo Incubation process.

11.1. GDAL and OGR
GDAL and OGR are best known as the vector and raster Geographic Data Abstraction Libraries used by many open source and proprietary applications. However, the functions are also accessible as command line utilities to translate and process a wide range of vector and raster geospatial data formats.

11.2. GeoTools
GeoTools is used by most Java based Geospatial applications. It provides standards based geospatial data structures, connectors to numerous data stores, data manipulation and rendering functionality.

11.3. MetaCRS
The MetaCRS project is actually a collection of five different projects which provide algorithms to transform between different coordinate systems.

11.4. libLAS
libLAS is a C/C++ library for reading and writing the LAS LiDAR format. LiDAR, or Light Detection and Ranging, is a form of high precision range detection, much like radar or sonar, that uses laser light as the electromagnetic emission.

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Find out more at http://live.osgeo.org or contact Gavin Fleming, AfriSpatial, Tel 021 863-0660, gavin@afrispatial.co.za